Development in the IAEA Containment and Surveillance Scheme at LWRs in Korea

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1. Introduction

Korea and the IAEA launched an innovative enhanced co-operation on safeguards approach as a membership support program on LWR in 2001. This new partnership utilizes the remote monitoring (RM) on the containment and surveillance system (C/S) at light water reactors (LWR) in Korea where the data are transferred to the IAEA and KINAC (the predecessor of TCNC, KAERI), simultaneously. This program is based on a joint-use equipment and data sharing plan. The RM based C/S system was being implemented through a few modifications for seven years after the integrated safeguards (IS) started. The enhanced co-operation was replaced by new arrangement. The IAEA proposed the use of unannounced inspections (UI) along with roaming camera concept to install temporary surveillance cameras instead of permanent installation at LWRs in 2013. New C/S system with no use of RM has been applied from 2015 to the present.

2. C/S System at LWRs

C/S techniques, based mostly on optical surveillance and sealing system with no need to access nuclear material. They are applied to supplement nuclear material accountancy. They reduce inspection costs and the level of intrusiveness of the IAEA into normal operational activity of nuclear facilities under safeguards [1]. RM system (RMS) on C/S collects safeguards data using unattended monitoring equipment and transfers them to a headquarters or branch offices for review. RM will provide less disturbance and reduces the frequencies of on-site inspection, compared with the conventional inspection. RMS, in general consists of digital seals and sensors which can check any events and digital cameras to identify events.

2.1 C/S System under the Comprehensive Safeguards Agreement

The MSSP for an enhanced co-operation on Safeguards implementation at LWRs between Korea and the IAEA initiated in 2001 [2]. It was agreed to take into account mutually beneficial approaches to make use of Korean SSAC participation in the Safeguards inspection. This program is based on a joint-use equipment and data sharing plan in parallel with on-going digital surveillance camera upgrade. The IAEA installed digital surveillance cameras and electronic seals capable of remote data transmission at Hanbit #3 power plant for the first time in 1998, and expanded to 11 LWRs in operation in 2001. Korea provided/installed seal platforms, conduits, splice boxes, communication lines, uninterruptible power supplies, design change, and the cost of VPN. RM tasks were applied to all LWRs along with data transfer to the IAEA headquarters and KINAC (the predecessor of TCNC, KAERI) central monitoring center, simultaneously in 2002. In traditional safeguards approach, C/S System is based on RMS with the virtual private network (VPN) in Fig 1. They are composed of two digital cameras (DCM-14 surveillance cameras), two electronic seals (VACOSS seals), one data transfer server with a data storage unit (a SDIS server) and a VPN system. Two surveillance cameras were installed to moniter muclear materials inside reactor building and inside spent fuel builing, separately. Two electronic seals were likewise installed at equipment hatch inside reactor building and at the canal gate inside spent fuel builing, separately.

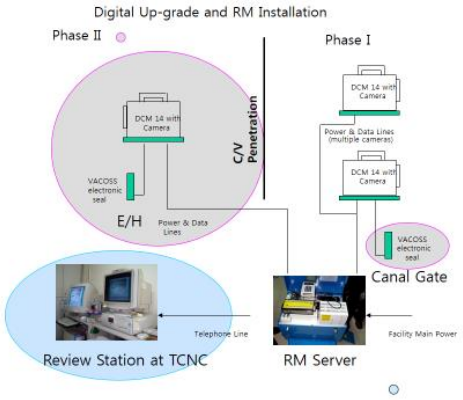

Fig 1. RMS installed at LWRs

2.2 C/S System under Integrated Safeguards Approach

The Additional Protocol was in force in Korea in 2004. With the Broad Conclusion, IS was applied on July 1, 2008. Both sides had prepared new approaches under integrated safeguards from the "First ROK-IAEA Integrated Safeguards Working Group Meeting in March 2005". The agency developed three options for LWRs without MOX, as in the following [3].

- Unannounced random interim Inspection and no-surveillance (ISP-1) during closed core period.

- Random interim inspection (short notice) with RM (ISP-2).
- Random interim inspection (short notice) with surveillance in overwrite (ISP-3).

ISP-1 is the proposal, which uses temporary surveillance during refueling based on unannounced inspection. ISP- 2 makes good use of the RMS which were extensively installed at the facilities. They were already working at 16 LWRs (excluding four LWRs under construction) by the end of 2005. Korea preferred the ISP-2 option with RMS due to technical reasons where the systems are in place and operating, and appropriate experience was gained during implementation of RM under the enhanced co-operation. ISP- 2 was chosen at "3rd ROK-IAEA Integrated Safeguards Working Group Meeting in September 2005" [4]. ISP-3 is similar to ISP-2 but difference between them is that surveillance runs in an overwriting mode with no RM. The C/S system was applied through a few changes until 2016 when UI application was agreed. Table 1 shows the comparisons of three proposals.

Table 1. Safeguards approach alternatives at LWRs.

	Interim	Surveillance		Seals
		During refueling	Between refueling	
ISP-1	Unannounced	Yes (Temporary)	No	On reactor core
ISP-2	Announced random (1day~1 week notice)	Yes (Permanent)	Yes (with RMS)	On reactor core
ISP-3	Announced random (1day~1 week notice)	Yes (Permanent)	Yes (Overwriting)	On reactor core

2.3 C/S System under State Level Approach (SLA) Update

C/S Systems in RM mode were running at 33 nuclear facilities at LWR, CANDU reactors, and KAERI in 2013. The IAEA analyzed the installation/up-grade/ operation and maintenance expenditure of the total RMS at LWRs. The IAEA initiated the use of UI application with a roaming camera concept [5] where the current permanent cameras and backup cameras (ALIP camera) are replaced with temporarily installed roaming cameras, based on ISP-1 in Table 1. Accordingly, permanent surveillance with RMS has been ended, after consideration of the flexibility and cost effectiveness. The new arrangement specifies implementation of the UIs along with roaming camera approach. C/S measures under ISP-1 include:

- Core fuel is kept under containment measures (EOSS and metal seals).
- Core fuel and spent fuel are kept under temporary surveillance measures (stand-alone X-Cam cameras) during the refueling outage period.
- Stand-alone X-Cam cameras are installed when additionally needed as well.

Fig. 2 shows four temporary surveillance cameras (marks in red) which will be installed during refueling period. They are removed between refueling outage while the equipment hatch at core and canal gate are sealed by EOSS.

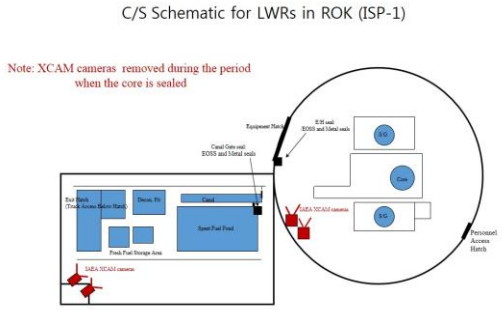

Fig.2. C/S schematic for LWRs.

RMS had been ended when the updated ROK SLA started on September 1, 2015. Remote data sharing on the C/S at LWRs was teminated as of Jun 20, 2016, too. Implementation of UI started after several field trials as of May 1, 2016 [6].

3. Conclusion

Since Korea and the IAEA launched an enhanced co-operation on Safeguards implementation at LWRs in 2001, the IAEA containment and surveillance approach proceeded to three stages; 1) C/S under traditional Safeguards. 2) C/S under Integrated Safeguards. 3) C/S under State Level Approach Update. Digital surveillance cameras and electronic seals based on RMS were adopted in replacement of analog systems under the Comprehensive Safeguards Agreement until 2008. Under IS, RMS based digital C/S system through a few modifications was continually utilized as an option (ISP-2) due to technical reasons. Under the SLA Update, UI in conjunction with a roaming camera concept (ISP-1) started in 2016. Only temporary roaming cameras with EOSS seals are used. Accordingly, existing permanent surveillance with RMS was ended. This approach is being operated up to the present.

REFERENCES

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